SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Accelerating transformative research to deliver Ireland's energy revolution

SEAI National Energy Research, Development & Demonstration Funding Programme

Final Technical Report

LOGIC-TIDE - LOGistical and Industrial Codesign for TIDal Energy

Project Lead
ORPC Ireland

Project Partners
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University of Galway
EireComposites Teo

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Executive Summary

Tidal energy offers a unique proposition as a fully predictable form of renewable energy. The global tidal stream resource potential, estimated to be around 1200 terra-watt-hours per annum, is lower than other sources of marine renewables such as wave and ocean thermal energy conversion. However, tidal stream technologies have progressed towards commercialization at a great pace and are expected to account for the bulk of ocean energy capacity installed by 2030. Tidal stream and other associated ocean energy technologies have generated interest from governments, investors and developers. ORPC is a global leader in the development of systems centred around a modular and efficient horizontally oriented cross-flow turbines. This project, LOGIC-TIDE, explored the cost reduction and performance improvement for ORPC's concept megawatt scale tidal energy converter (TEC), Optimor. Relying on guidance from current best practices and standards, the project specifically focused on the optimisation of three areas: the systems turbine rotor, the installation, maintenance and operation (I,O&M) and commercialisation potential of the system.

The International Energy Agency Ocean Energy Systems Framework for Ocean Energy Technology outlines 10 evaluation criteria to guide technology developers through relative stages of the systems design. The framework aims to build international consensus on ocean energy technology evaluation and guide appropriate and robust activities through the technology development process. The LOGICTIDE project addresses 7 of these criteria, and leans on the frameworks guidance to communicate progress to its funders and shareholders. The project featured key design activities for the structural assemblies, turbine rotor and buoyancy systems of the concept – whilst also considering the installation and maintenance of the system and the supporting infrastructure close to potential deployment sites.

Project progress was communicated to key industry stakeholders, including the Marine Renewables Industry Association (MRIA) and the TIDAL-GES (Tidal Energy – A transition to affordable and clean energy) research group. Engaging these entities ensured alignment with broader sectoral goals regarding "Good Environmental Status" (GES) within coastal and marine ecosystems. The resulting output from the project outlined over 70 possible supply chain partners within the target market locations, over 5 peer reviewed scientific papers and over 10 dissemination events where the LOGICTIDE project was mentioned.

At the end of the project, the Optimor system has advanced to the point where practical demonstration is the next step of design validation and verification (Stage 3). The project also borrowed best practice from the offshore wind sector, where the evaluation of the available installation infrastructure, composite manufacturing processes and testing best known methods were applied to the systems development.

Introduction

ORPC is a global leader in the development of marine renewable Energy (MRE) systems centred around it's modular and efficient horizontally oriented cross-flow turbines. ORPC has substantial experience in the design, installation, and operation of MRE systems – with numerous device installations globally since 2010. ORPC's approach to date has been to rely on the modularity of its cross-flow turbine design to increase power. This is suitable in small, community scale tidal projects, however, when servicing the utility scale market – a higher power requirement is present. A previously financed project by SEAI, addressed these scaling challenges to develop a concept design for a 2MW cross-flow turbine system design to maximise penetration in the utility-scale European market. This led to the patent protection of the concept developed in the project, and the pursuit of further advancing the technical development of the system.

The LOGIC-TIDE Project is a crucial step in the technical development of the Optimor device. The project lays the groundwork for future scaled deployments in European waters and reduces the technical risk associated by taking key considerations for the operations and maintenance of the system at an early design stage. LOGIC-TIDE has built on the unique, extensive experience that all LOGIC-TIDE partners have through various research and development efforts in the marine hydrokinetic field. These leading experts are composed of ocean energy technology developers (ORPC), marine composite design and manufacturers (ÉireComposites), offshore renewables operations experts (Rockall Research) & large structures testing researchers (University of Galway).

Other industry groups such as the Marine Renewables Industry Association of Ireland (MRIA), Tidal Energy – A transition to affordable and clean energy that can achieve 'Good Environmental Status' in coastal and marine waters project (TIDAL-GES) group which were informed of project progress. This allowed the project progress to be disseminated amongst both industry and the general public.

The Project kicked off in February of 2023, with the scope divided into three major research areas:

- Port infrastructure requirements for the installation and maintenance of the TEC system (2023/24);
- Design, build and test of a composite sub-component for a utility scale tidal system (2024/25);
- Supply chain and commercialisation activities for the device (2024/2025).

Considering these three avenues of product development at an earlier point, allows for effective development at a low-cost stage of the technology development.

The project consortium has years of research & development experience across all ocean technology development, advanced manufacturing and world leading testing facilities. This project builds on the application of this accumulated knowledge as well as the innovative ACCORD and OPTIMOR R&D projects that have set out a technical and market roadmap for developing the world's first economically viable crossflow turbines in the range of 1-2MW.

Project Objectives

The goal of the LOGIC-TIDE project is to accelerate the commercialisation of Optimor, a high potential cross-flow tidal energy converter (TEC) with a capacity of up to 2MW, to provide clean, predictable energy in support of Ireland's and Europe's decarbonisation and enterprise development efforts. To deliver this vision, the project consortium brought together a tidal energy developer (ORPC Ireland) at the forefront of the sector globally, supported by expert Irish supply chain companies, ÉireComposites and Rockall Research, and a world leading research organisation and testing infrastructure in University of Galway.

The development of a TEC system of this scale (1-2MW), requires systematic and staged product development that captures the areas of evaluation needed for the validation of the systems commercialisation. ORPC have adopted the world leading best practice from the International Energy Agency Ocean Energy Systems (IEA-OES) and incorporated its ten evaluation areas to the development of the system. Of the ten evaluation areas, LOGIC-TIDE addresses six of the criteria. The objectives of the project can be split into the following groupings:

Power capture, Manufacturability, Reliability & Survivability

Increasing the power capture of the TEC systems turbine is lauded as the single biggest factor of reducing the levelized cost of energy of a TEC system as it is developed[1]. The LOGIC-TIDE project aimed to design a high-preforming turbine through the development and refinement of numerical models to estimate commercial scale power capture performance.

Manufacturing partners ÉireComposites identified optimised design and manufacturing methodologies to deliver larger turbine foils up the 20m with the goal of large volume production. Furthermore a small-scale test turbine sub-component was manufactured, which was used to derisk critical manufacturing techniques and used for structural testing. The research team at the University of Galway operates the Large Structures Testing Laboratory, where they further developed capabilities relating to structural testing and advanced monitoring of tidal energy components, which contributes directly to the development of the next iteration of the IEC TS 62600-2 testing specification, along with building their research collaborations with ORPC Ireland. The main research objective of the University of Galway within the project was to confirm design condition boundaries and undertake physical laboratory testing of the key foil-strut interface to evaluate its structural integrity.

Process efficiency: Maintainability, Installability & Manufacturability

Rockall Research has considerable experience in the research and development of offshore renewable technologies, in particular wave energy, floating offshore wind and floating solar. The LOGIC-TIDE project will allow Rockall to apply its previous experience to tidal energy technology and also offer the opportunity to learn from and about this sister industry, thus strengthening its offering to its customers and new customers alike. This objective led to the identification of key I,O&M characteristics to inform critical parameters of the Optimor device design and identify the most appropriate infrastructure to support projects in Ireland and the UK.

[1] https://cms.ore.catapult.org.uk/wp-content/uploads/2022/10/Tidal-stream-cost-reduction-report-T3.4.1-v1.0-for-ICOE.pdf

Research Outcomes

Describe how your project has furthered the current state-of-the-art, current knowledge or current practice. Clearly highlight the degree of novelty and innovation demonstrated by your project.

The LOGIC-TIDE project has been a crucial step in the technical development of the Optimor device. The project has laid the groundwork for future scaled deployments in European waters and reduces the technical risk associated by taking key considerations into the installation, operations and maintenance (I,O&M) and manufacturability of the system at an early stage. I,O&M is often considered amongst secondary design priorities in offshore renewables with the focus often placed on CAPEX and power performance. However, due to the constraints of offshore conditions on operations, OPEX can constitute more than 40% of the levelized cost of energy (LCOE). The relatively small size of Optimor and its variants was found to offer the technology various options for deployment and recovery in terms of port facilities and vessel requirements. This indicates ORPCs technology could be deployed from many locations without the need for specialist equipment and vessels that are not readily available. This information fed into the development of a high-level deployment and recovery story board but more detailed work is required, especially in the area of cost assessment, to feed into the design the parameters of Optimor and to optimise its overall LCOE. Rockall has gained considerable experience investigating ports and harbours for ORE, and while tidal devices maybe of a similar size to wave energy they differ in terms of locations and characteristics of their deployment sites, which changes the relative influence of key OPEX parameters. Optimor is significantly smaller than a floating offshore wind turbine and therefore has almost none of their arduous deployment requirements and constraints.

A sub-section of the Optimor turbine was manufactured from carbon fibre reinforced polymers by ÉireComposites using oven-cure materials, consistent with the intended manufacturing approach for the Optimor device rather than autoclave processing. A cost-effective tooling and manufacturing method was developed of this component which enabled the development of a split-mould co-curing methodology allowing a thicker wall to be laid up while incorporating internal bracing plies to achieve robust bond lines – consistent with future lay-ups for the scaled turbine being developed utilising SEAI funding.

This sub-component was then tested under controlled laboratory conditions to evaluate its structural and dynamic behaviour during progressive loading. Strain was monitored using electrical strain gauges, fiber Bragg gratings (FBGs), and Digital Image Correlation (DIC), while deflection was recorded with string potentiometers and LVDTs. Several FBG sensors were damaged during the manufacturing process; the cause remains unclear. The remaining FBGs and strain gauges showed excellent correlation, validating their reliability for strain measurement. Dynamic properties were assessed using a laser scanning vibrometer to track natural frequencies throughout the loading sequence. Although the applied load ultimately caused failure of the specimen, the natural frequencies exhibited only minor changes despite clear evidence of damage and structural degradation. This novel finding suggests that global dynamic characteristics was largely unaffected by localized damage and challenges conventional assumptions that modal frequency shifts are reliable indicators of damage in composite structures, highlighting the need for alternative health monitoring strategies for tidal turbine components.

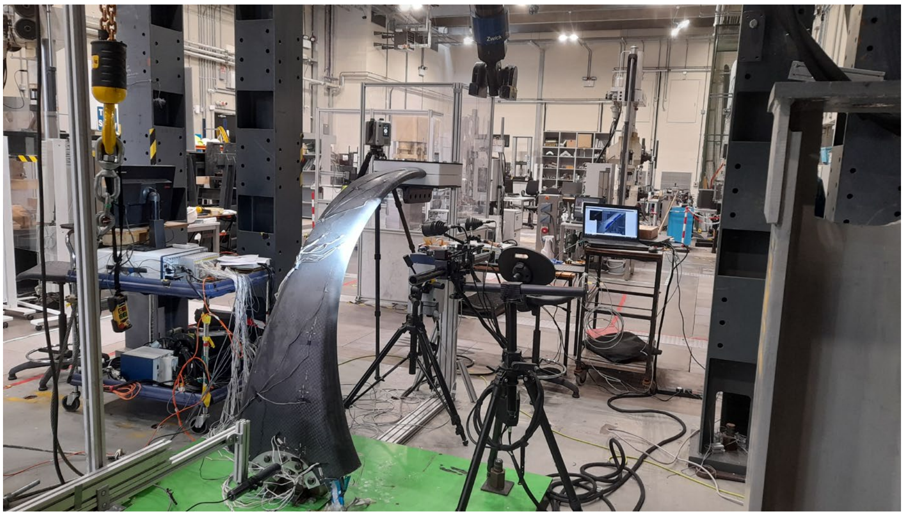

Figure 1 Composite test specimen being tested at the University of Galway Large Structures Test Laboratory

Project Impact

Clearly position the impact of your project with reference to the needs of the Irish Energy Sector, national and international policy objectives, and SEAI's remit.

The LOGIC-TIDE project has numerous impacts on both national and EU policy objectives. The further advancement of a novel tidal energy convertor aligns to the themes of decarbonisation of energy systems within society and the future security and sovereignty of energy sources. Specific policy points are addressed below:

Climate Action Plan, Action 123 - *Support the offshore and ocean energy research, development and demonstration pathway for technologies and associated test infrastructure.*
The LOGIC-TIDE collaborator profile utilized leading experts to influence the design of a future TEC system, capitalizing on previous experience in system development and also introducing TEC system development into other partners skillsets.

Programme for Government – *"Our Shared Future" "Produce a longer-term plan setting out how, as a country, we will take advantage of the massive potential of offshore energy on the Atlantic Coast".*
Outcomes from WP4 have assessed the local supply chain and Irish ports for the ability to support installation, operational and maintenance activities for future tidal devices in Ireland. Over 21 suppliers in Ireland alone were identified, with 73 identified in the EU. These span across the various fabrication methodologies mentioned in D6.1 'Supply Chain Report'.

National Climate and Energy Plan (NCEP) – *5MW ocean energy demonstration projects from 2023.*
LOGIC-TIDE has progressed the development of a multi-MW tidal device towards the point of practical demonstration at an appropriate scale. It is feasible that a single pre-commercial array of Optimor units would reach the 5MW target for ocean energy demonstration projects.

Offshore Renewable Energy Development Plan (OREDP) – *Action 5 Develop the Supply Chain for the Offshore Renewable Energy industry in Ireland Action 10 – Ensure Appropriate Infrastructure Development*

- Action 5: The projects has engaged three SMEs in the evaluation of the installability, maintainability and manufacturability of key components in the Optimor system. Lasting relationships and mutual development pathways for exploitation have been developed and are implemented in other research projects currently active under both SEAI and Interreg NEW funding.

- Action 10: The suitability of Irish ports has been identified and assessed for the deployment of Optimor showing promising ports around Ireland near high-capacity potential sites.[PC1.1]

EU Offshore Renewable Energy Strategy – *1 GW of Ocean Energy Capacity installed by 2030.*
The development of a multi-MW system for European deployment has clear alignment to this policy, with the Optimor concept representing a mid-water column device, rather than the current market leaders which are surface or bottom mounted systems. This will allow for further penetration of tidal energy in sites that are deemed unsuitable for surface and bottom mounted systems.

Eu Strategic Research and Innovation Agenda (SRIA) for Ocean Energy -
LOGIC-TIDEs outputs directly contribute to advancing the tidal energy sector across several of the Priority Areas set out in the SRIA:

- Improvement of tidal blades, rotor and chassis (WP2, WP5)
- Application of innovative materials from other sectors (WP3)
- Optimisation of maritime logistics and operations (WP4)
- Quantifying and demonstrating grid-scale benefits of ocean energy (WP6)

Discuss the key impacts of your project: societal, economic, technological, or otherwise. Clearly identify and highlight the value of your project in the wider context.

Tidal energy offers significant societal benefits by providing a reliable and predictable source of renewable power, reducing dependence on fossil fuels and contributing to long-term energy security. Its predictability, ensures stable generation compared to intermittent sources such as wind and solar, thereby enhancing grid stability and resilience. The deployment of tidal energy systems can stimulate local economies through job creation in manufacturing, installation, and maintenance. Furthermore, tidal energy projects can help coastal communities achieve greater energy independence, supporting national and global climate targets. When implemented responsibly, these projects can coexist with marine ecosystems, delivering clean energy alongside environmental stewardship and social progress. This is particularly relevant for Ireland, where the electricity grid is already highly reliant on wind energy, which is inherently unpredictable. Tidal energy therefore offers substantial potential as a complementary and stabilizing source for the Irish grid.

The development of a new tidal blade enabled preliminary studies on manufacturing processes for large-scale composite structures and on new materials suitable for the marine and energy sectors. The integration of novel technologies such as Fiber Bragg Gratings (FBGs) into composite structures contributes to improving national expertise in composite manufacturing. ORPC worked with a new supplier for the manufacturing of the joint parts, introducing a new sector of activities to an Irish manufacturer. The development of a new hybrid tooling (one-half composite, one-half epoxy-based) optimised the project's material cost without compromising the quality of the foil.

The Tidal-GES project conducted a study of the Shannon Estuary to assess tidal energy potential as a function of water depth. The analysis showed that using conventional axial-flow turbines, which typically require a minimum depth of around 27 m, would significantly limit the amount of energy that can be harvested within the estuary. In contrast, the Optimor turbine design features a shallower minimum depth requirement, enabling access to a greater number of viable energy sites. This advantage is likely applicable to many other tidal locations worldwide.

The development of OPTIMOR presents an opportunity to activate and expand a competitive European supply chain, with Ireland positioned to play a strategic role. Tidal energy naturally relies more heavily on local supply chains than other marine renewable industries, such as offshore wind. Due to the smaller scale of equipment, the proximity of resources to the coast, and the modular nature of tidal devices, a large share of components can be manufactured, assembled, and maintained locally. This characteristic makes tidal stream power a strong driver of regional industrial development. Building a strong supply chain in Ireland is essential not only to reinforce national energy sovereignty and ensure that value is created locally, but also to position the country among the global leaders in the sector. A robust domestic supply chain would also improve Ireland's position as an exporter of expertise and components, enabling Irish companies to benefit from the significant tidal resources available in neighbouring regions.

Recommendations

Please highlight any implications/opportunities/recommendations for Ireland (e.g., for policy makers, for the research community, for industry) based on the work carried out in the project.

Policy Makers

Irish research organisations and supply chain companies are recognised leaders in tidal energy technology development and have been valuable partners to ORPC's technology and project development activities both in Europe and the United States, through several national and EU-funded projects. As well as technology-focused R&D, ORPC is also focusing on project development opportunities in Ireland through its involvement in the TIDAL-GES project and previously SEAI funded tidal resource assessments of County Donegal and through other RD&D efforts in the ATEAM (RDD917) project.

The draft of the Second Offshore Renewable Energy Development Plan (OREDP II) lacks some of the ambition laid within the first draft of the plan, including removing initial market support tariffs for Ocean Energy. Given the growing maturity of tidal energy, and the presence of tidal energy technology and component developers in Ireland, there is a near term interest in developing tidal energy projects of relatively small scale (10-100s kW) in Irish waters to demonstrate the technology and to address applications currently under investigation – such as those within other projects currently underway led by ORPC.

Research Community

This study provides two key contributions to the research community. First, it validates the use of fibre Bragg gratings (FBGs) for strain measurement in composite tidal turbine connections, demonstrating excellent correlation with conventional strain gauges and confirming their reliability for structural monitoring applications. Second, it presents a novel finding regarding dynamic behaviour: despite severe localized damage and eventual structural failure, the natural frequencies of the specimen exhibited only minor changes. This challenges the widely held assumption that modal frequency shifts are sensitive indicators of damage in composite structures and underscores the need for alternative health monitoring strategies. Together, these results advance sensor validation for marine energy systems and open new avenues for research into damage detection methodologies.

Industry

The project has built on multiple years of experience between tidal energy technology developer, ORPC, and Irish supply chain partners, ÉireComposites, to further the development of advanced manufacturing for use in the tidal energy sector, in Ireland. The design methodologies chosen, which are compliant with the relevant IEC and DNV-GL standards, are part of a technology development pathway which is backed by international best practices through the International Energy Agency Ocean Energy Systems (IEA-OES) Framework for Ocean Energy Technology. The activities and evaluations presented in the various stages of this framework, reflect the increasing knowledge, confidence and funding required as a technology matures. The framework builds the foundations of a clear, unambiguous evaluation methodology. It is the recommendation of the consortium that this framework be adapted where ocean energy concepts and being conceived. The guidance of this framework, coupled with increased knowledge building between SMEs in the project, will allow for the future advancement of the manufacturability of the full-scale turbine build for the system. The LOGIC-TIDE project has also laid the foundation for decision-making based on OPEX as a driver which corresponds to advancing the installability and maintainability of the Optimor system.

Conclusions and Next Steps

Optimor's development pathway is guided by the IEA-OES Framework for Ocean Energy Technology, IEC (in particular IEC TS 62600-2) and DNV-GL standards, resulting in a structured process to guide the system to a safe and cost-effective advancement through its technology readiness. The LOGIC-TIDE project was formed to cover six of the ten areas of the IEA-OES framework, including: Power Capture, Reliability, Maintainability and Installability, Manufacturability, and Affordability. This systematic design process reduces risk and enhances the clarity of communication between technology developers, funders and investors.

The turbine design effort completed during this project has proven to be very insightful and valuable for optimising the turbine at an early stage. The results of this effort have been significant, with both weight and cost being reduced based on earlier concept approximations. The next steps in turbine development include material characterization and the optimization and manufacturing of a sub-scale turbine foil, which will be the largest cross-flow turbine component that ORPC have built to date. This will be achieved in the SEAI-funded TIDAL-HEALTH (RDD1098) project.

The work related to the installation, operation, and maintenance (IO&M) of the OPTIMOR concept increased the understanding of the challenges of deploying and operating a device in European waters. The screening of Irish and UK ports and harbours was completed in Work Package 4 and gave an overview of the main site characteristics and infrastructure available at or close to each site of interest. In order to reduce the LCOE of a commercial scale OPTIMOR, there is another layer of detail required. Further work is required to identify and quantify critical parameters for the deployment of buoyant and floating tidal energy devices. This work would include a design loop in which baseline device parameters of geometry, scale, mooring system etc., are defined together with deployment scenarios and supporting equipment requirements. Detailed work would then be carried out including hydrodynamic modelling of key offshore operation to define environmental constraint such as wave height on the offshore operations, there constraints would then be use in a logistics model which would simulate the operation and maintenance of the device in the deployment site's environmental conditions over its life cycle. This model would then be used as the base of the techno-economic model of OPEX. This can then be included in ORPC's LCOE model which can be used to optimise the device parameters.

ORPC are currently involved in three other nationally funded research projects relating the development of the Optimor system. These advance the status of the Optimor system to 'Stage 3' – which describes the practical demonstration of the device in conditions similar to that of the full-scale unit. Outputs from these various projects aim to safely and cost-effectively demonstrate the technology in an appropriate test site. ORPC have previously collaborated with Queens University of Belfast's Marine Laboratory in Portaferry and utilized their test-site in Strangford Lough. This is a frontrunner for the future deployment of the Optimor system in Ireland.

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